FrInGe

Deutsches Interferometriezentrum

für den optischen und infraroten Wellenlängenbereich

Heidelberg

Frontiers of Interferometry in Germany
Heidelberg
AIP · AIU · KIS · MPE · MPIA · MPIfR · UK
Tel: +49-6221-528 264
Fax: +49-6221-528 246
http://www.mpia.de/FrInGe

FrInGe

Frontiers of Interferometry in Germany

German Center for Infrared and Optical Interferometry

Date: 1st October 2001

Version: Final

1 Scope

The German Center for Infrared and Optical Interferometry called FrInGe was created in September 2001. Its aim is to co-ordinate efforts by German institutions in obtaining, reducing and interpreting astronomical interferometric data from optical to mid-infrared wavelengths. Currently, interferometric efforts in Germany concentrate on instrumentation for the Very Large Telescope Interferometer (VLTI) (especially MIDI and AMBER), the Large Binocular Telescope (LBT) interferometric capabilities (especially LINC), and on contributions to the planned space interferometer DARWIN.

The scientific goal of the interferometry instruments is to reach unprecedented spatial resolution in order to reveal the structure of important classes of astronomical objects such as active galactic nuclei and starburst galaxies, protostellar cores and protoplanetary disks, stellar environments, and the dusty envelopes around evolved stars. In addition, precise astrometry will allow the detection of moving structures, especially the motion of stars caused by orbiting planets. The primary goal of the DARWIN mission will be the detection and imaging of terrestrial exoplanets and the characterization of their atmospheres.

FrInGe will gather tools and software developed across the participating institutions and provide a unified tool-set for preparation, planning, data handling and reduction, and interpretation of interferometric observations to the community. FrInGe will be responsible for training the next generation of astronomers active in optical and infrared interferometry.

In parallel, FrInGe will define the requirements for new and/or upgraded interferometric instruments on ESO and LBT facilities. The Center will serve as a point of contact for industrial partners in Germany, which want to contribute to astronomical projects in interferometry. FrInGe will provide the environment for developing and supporting new instruments.

FrInGe will seek to establish co-operations with other interferometric centers in Europe. The long-term perspective is to establish a European interferometric center for infrared and optical interferometry that can supply services to the community across Europe.

2 Participating Institutions

FrInGe will be located at the Max-Planck-Institut für Astronomie (MPIA) in Heidelberg. The participating institutions are:

- AIP - Astrophysikalisches Institut Potsdam
- AIU - Astrophysikalisches Institut und Universitäts-Sternwarte, Friedrich-Schiller-Universität Jena
- KIS - Kiepenheuer-Institut für Sonnenphysik in Freiburg
- MPE - Max-Planck-Institut für extraterrestrische Physik in Garching
- MPIA - Max-Planck-Institut für Astronomie in Heidelberg
- MPIfR - Max-Planck-Institut für Radioastronomie in Bonn
- UK - I. Physikalisches Institut der Universität zu Köln

FrInGe welcomes the participation of additional German institutions which want to join.

3 Structure

3.1 Staff

FrInGe has a scientific and technical head. Both will manage the activities of the center in their respective fields and the relations with similar institutions abroad. Additionally, there will be a scientific council, composed of four members coming from the participating institutions. This council will set priorities on the science activities of FrInGe. The policy of FrInGe for establishing contacts, co-ordination and co-operation will be defined by an executive board, composed of the directors of the participating institutions and the scientific and technical coordinators of the center as ex-officio members.

- Scientific Coordinator: Thomas Henning (AIU/MPIA)
- Technical Coordinator: Uwe Graser (MPIA)

Scientific Council:

- Andreas Eckart (UK)
- Christoph Leinert (MPIA)
- Gerd Weigelt (MPIfR)
- Hans Zinnecker (AIP)

Executive Board:

- K.G. Strassmeier (AIP)
- N.N. (AIU)
- O. von der Lühe (KIS)
- R. Genzel (MPE)
- Th. Henning (MPIA)
- G. Weigelt (MPIfR)
- A. Eckart (UK)

3.2 Manpower & Funding

The startup funding for establishing the FrInGe center will come from the MPIA in Heidelberg. This institute will offer the necessary administrative infrastructure for running the center. With growing duties, the need for one to a few additional positions is expected. Apart from contributions by the partner institutes, FrInGe will participate in efforts to establish European networks and to get funding from European science projects. We will seek for funding from the German “Verbundforschung Astronomie/Astrophysik”, the DFG, the DLR, private foundations, and industry. We will consider adding a prize fellowship to the center.

3.3 The Center

FrInGe will have its headquarter in Heidelberg. It is planned to have:

- A dedicated point of communication contact (e-mail, fax, Phone)
- Central public computer servers for:
  - Web server for information about the center and its activities
  - Tutorials for interferometry
  - Description of instrumentation currently being developed in Germany
  - Distribution of tools and software for the community
  - A database about publications resulting from interferometric observations
- Central internal computer servers for:
  - A database of planned and completed interferometric observations
  - Communication between participants (Discussion boards)
  - Description of future projects and project applications to funding agencies

4 Aims

The center will co-ordinate efforts of the participating institutions in the following fields:

- Help to react in a timely fashion to new developments in the field and to prepare and support new instruments
- Help to establish contacts and co-operation with other, similar institutions such as the Dutch interferometric center in Leiden, or the Jean-Marie Mariotti Center in France.

- Provide a central interface for contacts and co-operation with ESO and the LBT project
- Keep a database of interferometric observing programms conducted and planned by the participating institutions. It is agreed that the center will not interfere in observing proposals of possibly competing parties and will provide the database for mutual information only.
- A publication archive
- Development of software for planning observations, data storage & handling, data reduction, and interpretation of results.

In each of the participating institutions, activities in these fields have been going on for several years. With the recent first light of the VLTI successfully accomplished, the advent of the first science data from the VLTI interferometers MIDI and AMBER is drawing nearer.

In interferometry, the processes of planning and scheduling observations, data reduction and interpretation are much more tightly connected than in traditional astronomy. In fact, the technique of data interpretation is strongly influenced by the very design of the instrument – and vice versa. MIDI, built at the MPIA, is a two-beam-interferometer that measures visibilities. Such observations need to be carefully planned using *a priori* knowledge (from modeling) of the target to focus on the "interesting" part of the visibility curve. These visibilities have to be calibrated by observations of suitable standard sources. Interpretation of the visibility curves requires simple models and questions.

In a second step, MIDIII, under development at the MPIA, will have imaging capabilities.

AMBER, built by an international consortium of groups at the universities of Grenoble, and Nice, the Arcetri observatory and at the MPIfR, is a three-beam phase closure instrument for the J-, H-, and K-band.

Data from these instruments will allow the reconstruction of real images (still hampered by the lack of u-v plane coverage, of course). So far no user-friendly image reconstruction software is available. In the future, we will strongly support the establishment of improved imaging capabilities at the VLTI.

Interferometry on the LBT presents its own unique set of challenges. Because the two telescopes are on a single mount, the LBT allows Fizeau interferometry, which is not limited by geometric delays across a large field. The LBT and VLTI are complementary, since the LBT samples the shorter baselines which are inaccessible to VLTI.

The point spread function (PSF) of the LBT interferometer is quite complex, however. Processing such imagery will require a number of software tools for the optimal extraction of object brightness distributions from several frames taken at different position angles. And, since the LBT interferometer depends on the earth's rotation to present different object position angles, advanced scheduling tools will be necessary to take maximum advantage of precious LBT observing time.

The MPIA is leading an international consortium of institutes in building LINC, the LBT INterferometric Camera. LINC will combine the radiation from the two 8.4 m primary mirrors of the LBT in so-called "Fizeau" mode. This configuration preserves phase information, and allows true imagery over a wide field of view. LINC will operate at wavelengths between 0.6 and 2.4 microns, using state-of-the-art detector arrays. When coupled with the advanced adaptive optics system of the LBT, the LINC instrument will deliver the sensitivity of a 12 m telescope and the spatial resolution of a 23 m telescope, over a field approximately 20 arcseconds square.

Through their participation in the LBT project, astronomers in the FrInGe center will have access to an additional nulling interferometer by the end of 2005. This instrument, currently under construction in Arizona, will complement efforts underway at the VLTI. Not only will the LBT nuller give German astronomers access to northern hemisphere targets, but also it has a spatial resolution better suited to resolving extrasolar zodiacal light clouds. Understanding such dust clouds is an important prerequisite to selecting targets for future space interferometry missions such as DARWIN.

5 Software Projects

Software packages will be developed for five stages of interferometric observations:

- Preparation of observations
- Scheduling of observations
- Data handling & reduction
- Interpretation (Modelling)
- Image Reconstruction

5.1 Preparation

5.1.1 Sim*VLTI*

Sim*VLTI*, currently under development at MPIA, is a simple tool for the planning of observations. It allows the input of model maps for any target and provides computed visibilities for a number of observing parameters. Currently, Sim*VLTI* supports input maps in a number of formats (fits, standard image formats, a few raytracing code formats), any configuration of the 4 UTs and the basic operating modes of the MIDI detector. There is also a rudimentary interface for Sim*VLTI* to be used as a tool for model interpretation of real data.

Planned upgrades include the integration with existing technical observation preparation tools under development at ESO (to provide access to AT configurations, technical constraints on observations from delay line strokes, etc.). It should be useful to include simulations of atmospheric effects on the observations.

5.1.2 Scheduling of observations

Interferometric observing will require a new paradigm, since we have considerably less freedom in scheduling our measurements. For example, we may need a particular position angle on a particular source, then move to grab another position angle on another source for a while, then return. Optimal use of the telescope time will therefore require new scheduling tools.

5.1.3 Calibrators

The new interferometric instruments on the Keck and VLTI telescopes will observe fainter objects and at longer wavelengths than the existing smaller-telescope interferometers (CHARA, COAST, GI2T, IOTA, PTI). Efforts to produce lists of suitable calibrators and of sources unsuitable for calibration are under way at various places, including the MPIA, ESO, the AMBER team, and the IAU Working Group on Optical/IR Interferometry (http://olbin.jpl.nasa.gov/iau). The center will channel the information from these sources, with emphasis on improving the little developed status for the mid-infrared range.

5.2 Data handling & reduction

The steps leading from pixel values to raw visibilities in large part are special to each instrument and closely related to hardware, and therefore less suited to exchange. Nevertheless, the center will collect and support algorithms for more general applications. The efforts of the aforementioned IAU working group to facilitate data exchange, for example by agreeing on common formats for calibrated data, deserve support.

5.3 Interpretation (Modelling)

5.3.1 Radiative transfer models

Groups in Bonn and Jena have developed 2 and 3D radiative transfer codes based on traditional grid methods and the Monte-Carlo technique. These codes are presently used to predict images and visibilities. In addition, simple geometric models and models assuming a simple dependence on physical parameters, for example, the temperatures of the components of a binary star, should be made available to analyse interferometric data.

5.4 Image Reconstruction

The strength of VLTI will strongly increase with imaging capabilities using at least 4 to 5 telescopes. The present plan is to have 7 telescopes (4 UTs and 3 ATs) with possible extension to more ATs and longer baselines. Observations with larger number of telescopes probably will be done in parallel in groups of three and four. FrInGe will participate in the definition of the future imaging capabilities of VLTI and prepare tools to get images from these sparsely sampled data.

6 Future instrumentation projects

Another goal of FrInGe is the preparation of the next generation of interferometric instruments. The following projects are under development:

- Extension of MIDI to 20 micron and design of MIDI II which should have imaging and nulling capabilities — MPIA
- Participation in the definition of new imaging capabilities of VLTI
- Participation in the preparation of the DARWIN mission, beginning with the definition phase of the ESO/ESA nulling testbed for DARWIN